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Design of Production Systems

FrancoAngeli

ECONOMIA & MANAGEMENT

Informazioni per il lettore

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1. Introduction to industrial production systems

1.1. Industrial production

Industrial production represents the point where the two key business processes of an industrial company (see Figure 1.1) intersect: ***New product development process*** (vertical dimension) and ***Logistics & Production process*** (horizontal dimension). The two main activities of industrial production are: i) design of the production system and ii) management of the production system.

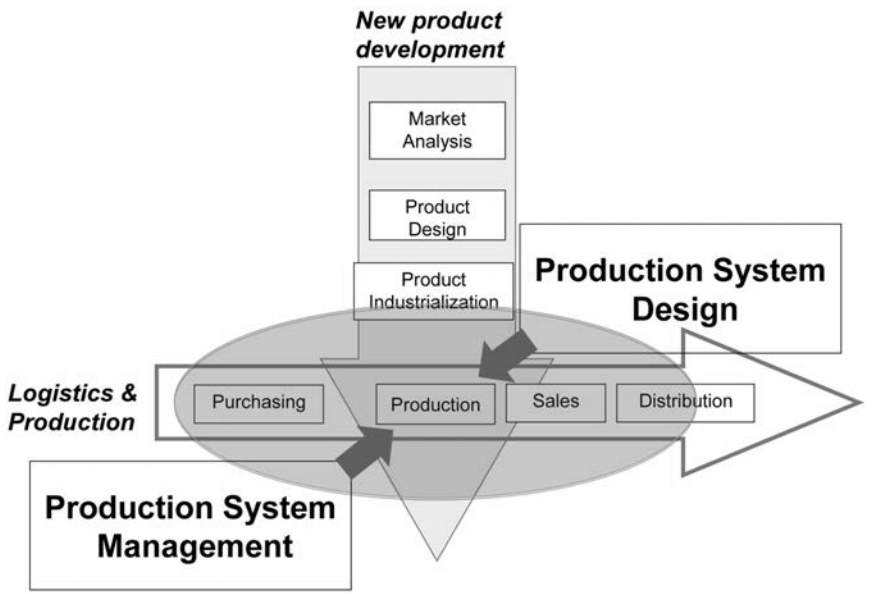


Figure 1.1 - The two key business processes of industrial production

1.2. The production process

An industrial factory, which can be defined in equivalent terms as an industrial production system, is a combination of resources (both equipment and personnel) that allows performing an industrial production process, for example, the transformation of raw materials into finished products (economic goods) based on a defined industrial technology.

On the other hand, industrial technology can be defined as the knowledge on which the physical/chemical/organizational process allowing the transformation of raw materials into finished products is based. This involves significant changes in the chemical and physical properties of incoming raw materials.

Production process is the transformation activity performed on raw materials and it is based on a defined industrial technology, which is implemented through proper equipment. Energy and information are both required for the process activity to happen. The realization of the industrial production process is performed within an industrial production system (industrial factory) and it requires the presence of the following main elements (see Figure 1.2):

- various types of equipment and related plant service infrastructures that constitute the means which carry out the technological transformations;
- energy that is used to make the changes happen;
- personnel (operators, supervisors, managers), who implement and control the process thanks to their different skills;
- information that circulates into the system and allows a proper management of the process (by using manual or computer systems that control the production plan, the working equipment, etc.);
- raw materials that enter the transformation process to be converted into finished products.

Then, the finished product is sold into the market and the sales revenues are used for the payment of the incurred costs, the recovery of invested capital and the generation of profit, thus allowing the stability of the production cycle.

Definition: A *production system* is a set of machines and assets that implements an industrial production process through an industrial technology in order to manufacture goods.

Usually, a production process consists of several stages that can be divided into three main types:

- acquisition of raw material to be used for production;
- transformation of raw material into product;
- distribution of the product on the market.

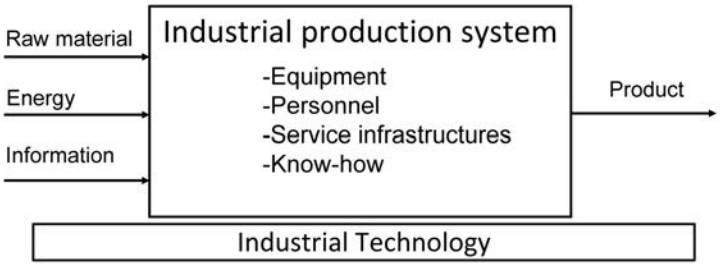


Figure 1.2 - Schematic view of an industrial production system

The second stage is to be considered when analyzing the manufacturing process from a technological point of view. Transformation takes place inside the industrial factory, while the two other phases involve exchanges with the outside: suppliers in the first case and customers in the second one. In turn, the transformation phase can be divided into various processes:

The first type of process is the conversion or processing stage, in which raw materials are converted into finished products. In the case of the process production type of production (see the following chapters for details), the raw material is processed to obtain a different material (for example, in the cement production limestone and clay are converted into cement thanks to the chemical reaction developed between them at about 1350 °C in the rotary kiln). Otherwise, in the case of the discrete manufacturing type of production (see the following chapters for details), raw materials are used to manufacture various parts (components), which are then assembled together to create the finished product.

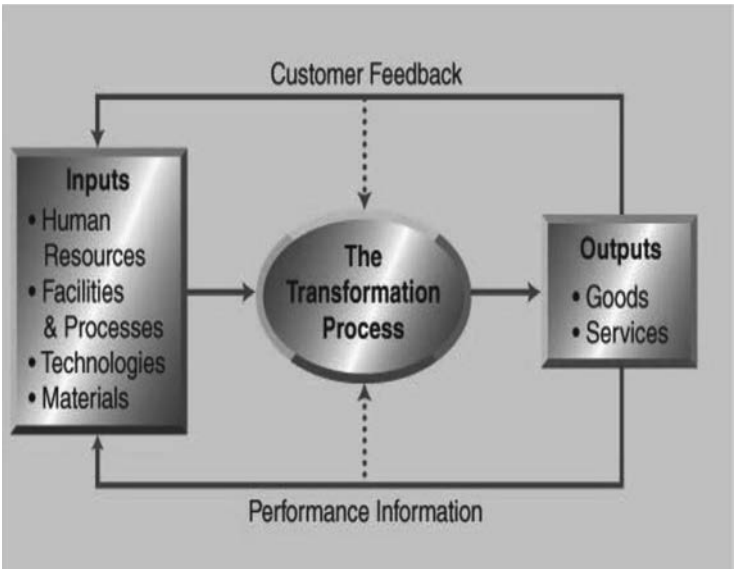
The second type of process is the storage or waiting stage, in which the processed material is stored while waiting to undergo a subsequent processing phase (in the case of semi-finished products) or before being distributed on the market (in the case of finished products).

The third type of process is constituted by transportation that allows the succession of different stages of conversion.

(Note: depending on the type of process, some of the previous stages may not be required).

Obviously, control is necessary during the process execution to avoid errors or irregularities that would compromise the quality of the product.

Definition: from a more general point of view, a *production process* is a transformation process by which a set of resources (process inputs) is converted into goods and/or services (process outputs).



Source: Reid & Sanders

Figure 1.3 - Schematic view of a production process

In fact, the transformation process may involve different types of transformation:

- physical (e.g. machining);
- chemical (e.g. pharmaceutics);
- location (e.g. transport);
- exchange (e.g. retail);
- storage (e.g. warehousing);
- physiological (e.g. health care);
- informational (e.g. telecom).

1.3. Representation of production process

A production process can be analyzed by considering its characteristics in many ways and various graphical representation methods have been developed to visualize them. Among them, the main representation solutions aim at representing the physical aspect, the technological aspect and the procedural (or managerial and organizational) one.

1.3.1. *Physical aspect*

The physical aspect of a production process corresponds to the view of the process from a static standpoint. It describes the set of physical units of the production system, without considering other elements of technological or managerial nature. The typical tool used to represent the physical aspect is the layout, which corresponds to a plan drawing of the plant. The layout allows getting an idea of the arrangement of the various operating workstations of a production system. A lay-out can be structured as a general (or schematic) lay-out when it contains a schematic representation of the different areas that make up the system with an approximate indication of the shape and dimension of these areas (as in Figure 1.4). It can also be structured as detailed lay-out (which may of course be more or less detailed), in which case the lay-out functions as a representation with a high degree of realism of the various components of the plant (i.e machines, structural elements, transfer areas, storage locations, etc.).

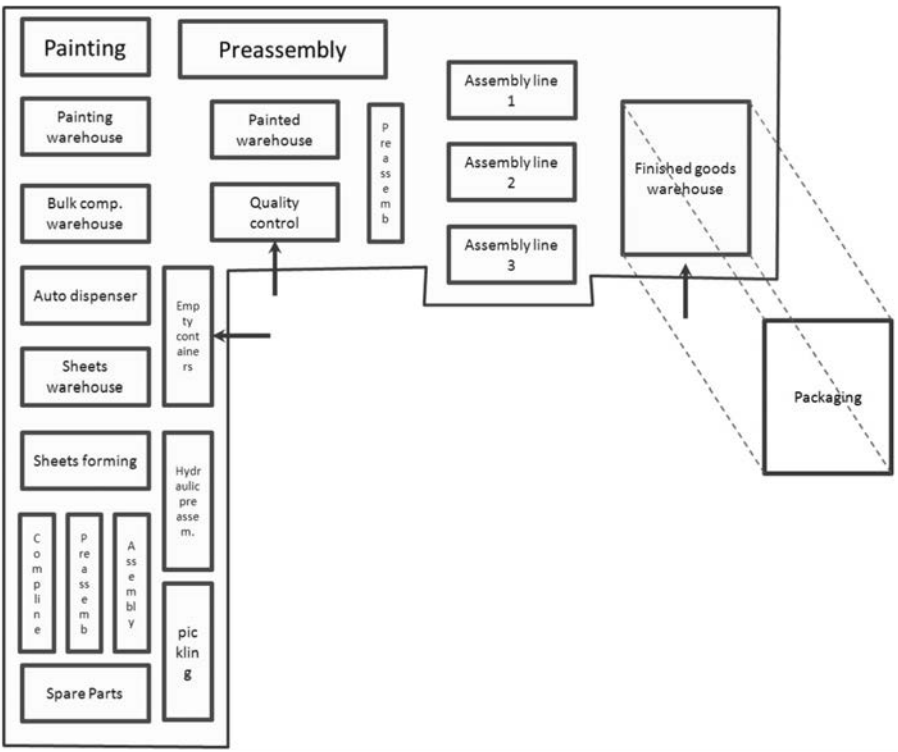


Figure 1.4 - Example of the schematic layout of a plant for boilers production

1.3.2. *Technological aspect*

Production processes are multistage processes. This means that a sequence of operations is required to realize the process to obtain a product from the raw material (e.g., a rotating shaft from a steel bar though various machining operations or a plastic bottle from a series of chemical–physical transformations). The set of data that describes the sequence of such operations is called technology cycle or technology routing. The technology diagram is also used to describe graphically the various processing steps of a technology routing.

The ASME symbols described in Figure 1.5 are typically used for representing a technology diagram. The technology diagram can be drawn in the form of both a qualitative and a quantitative diagram. The qualitative technology diagram describes the relationships between the various processes, describing only the flow required for product realization (see Figure 1.6 about the cement production process). On the other hand, the quantitative technology diagram represents the flow amount of materials (or energy, or any other useful parameter) used in the different processes (typically referring to the unit product output. Therefore, this representation can be used as a guidance when dimensioning a process.

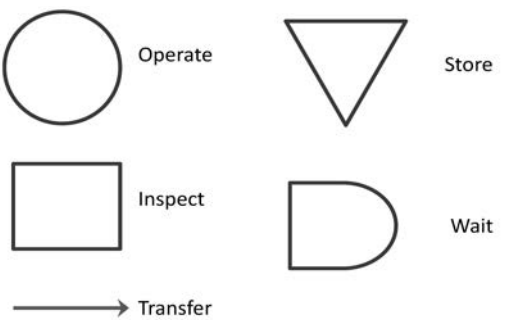


Figure 1.5 - ASME (American Society of Mechanical Engineers) symbology

The way the sequence of operations is organized depends on the type of flow, which can be of different kinds: sequential type (e.g. mechanical machining), analytical type (e.g. refining process) and synthetic type (e.g. assembly process). The flow sheet is another way to describe a technology process. In the flow sheet the different sections of the production system, through which the product flows during its production cycle, are graphically represented through schematic drawings of the equipment in charge of the processing activity (see Figure 1.7).

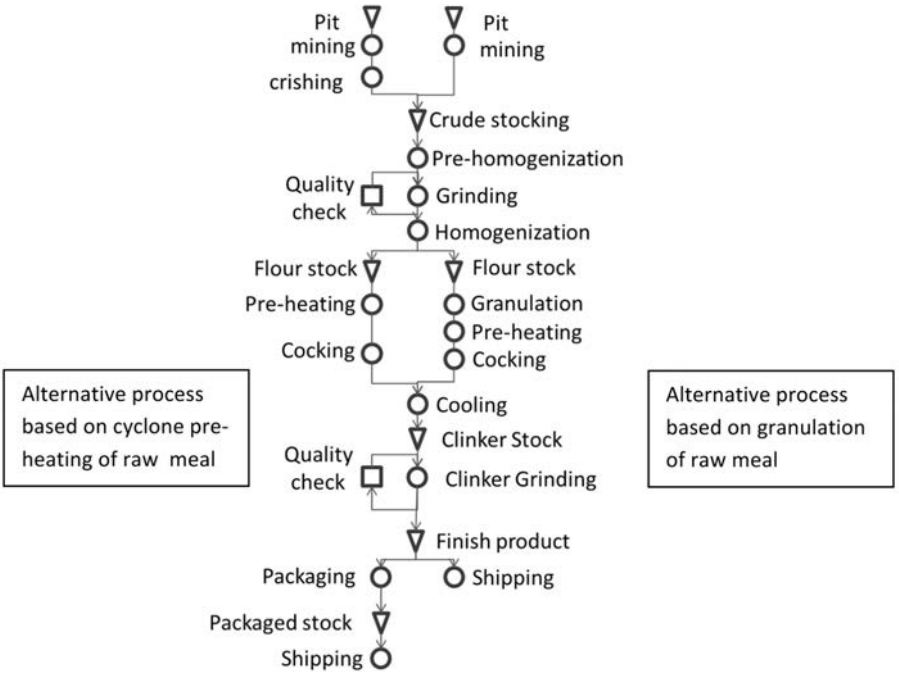


Figure 1.6 - Example of a qualitative technology diagram (cement production)

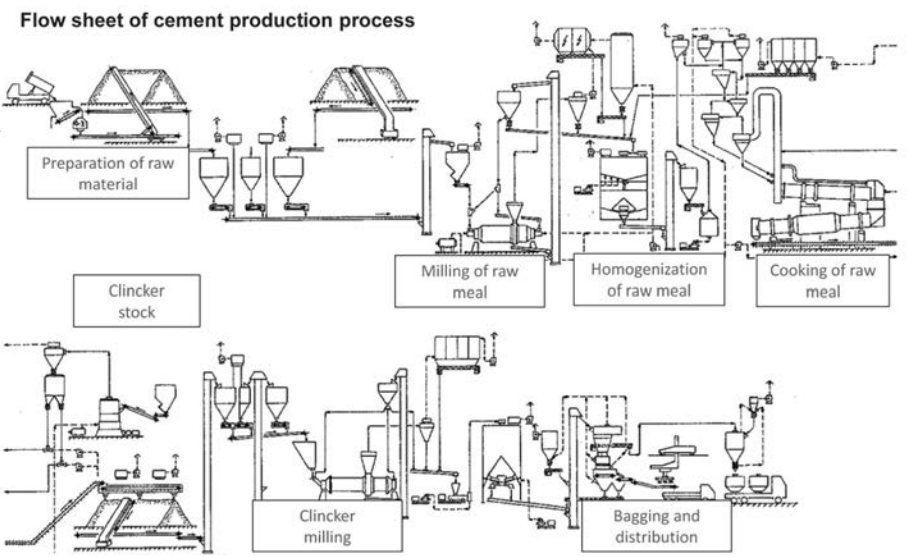


Figure 1.7 - Flow-sheet of the cement production process